THE RELATIONSHIP BETWEEN ANKLE LAXITY AND FRONTAL PLANE ANGLES DURING NETBALL SPECIFIC TASKS: A PILOT STUDY

Alison S. Attenborough[1], Peter J. Sinclair[1], Claire E. Hiller[2] and Richard M. Smith[1]

Discipline of Exercise & Sport Science, The University of Sydney, Australia[1]
Arthritis & Musculoskeletal Research Group, The University of Sydney, Australia[2]

Ankle sprains are common in netball and, if quantified mechanical ankle laxity can be linked with ankle kinematics during common netball landing tasks, then preventative measures can be implemented to reduce the occurrence of such injuries. Four netball players had their ankle laxity measured with an ankle arthrometer and performed two landing tasks (a cutting manoeuvre and a linear running task involving a ball catch and sudden stop) within the 3D motion analysis laboratory. The participant with the highest arthrometry measured ankle laxity angle displayed the highest frontal plane range of motion during both landing tasks. A high correlation coefficient (R^2=0.84) was found when comparing arthrometry measures with frontal plane range of motion during the cutting task. Although a promising relationship was observed, larger sample sizes are needed for more conclusive results.

KEYWORDS: kinematics, landing, cutting, sport, range of motion, inversion

INTRODUCTION: Netball is a multidirectional court based sport that is highly popular amongst countries of the British Commonwealth. An ankle injury is the highest reported injury to netball players (Ferreira & Spamer, 2010), with ankle sprains being the most common diagnosis (Fong, Hong, Chan, Yung & Chan, 2007). External prophylactic ankle supports in combination with a standard netball shoe have been found to reduce ankle range of motion during a netball landing task when compared to solely wearing a standard netball shoe without any additional support (Vanwanseele, Stuelcken, Greene & Smith, 2014); however, the strategic use of ankle braces provides no insight as to how the ankle might function without support.

The mechanical integrity of the ankle following an acute sprain is classically understood in terms of a lax joint. Ankle arthrometry provides an objective and highly reliable (Kovaleski, Gurchiek, Heitman, Hollis & Pearsall IV, 1999) measure of joint laxity in anterior-posterior and inversion-eversion directions. A high inversion-eversion arthrometry angle (≥36.8 degrees at ±3Nm) has been found to be a risk factor for sustaining an ankle sprain during netball participation (Attenborough et al., 2015) although it is currently unknown whether inversion-eversion arthrometry values affect frontal plane angles during the landing of sport specific functional movements commonly utilised in netball.

The present study aimed to observe the relationship between inversion-eversion arthrometry measured ankle laxity and frontal plane ankle range of motion during two movement patterns specific to netball.

METHODS: Four club level netball players (23.3 ± 2.8 years, 1.7 ± 0.1 m, 77.3 ± 9.9 kg) with netball playing experience ranging from 9-19 years volunteered for the current study at the Biomechanics Laboratory within The University of Sydney.

An instrumented ankle arthrometer (BlueBay Research, Milton, FL) was used to measure laxity at the ankle in an inversion-eversion (IE) direction before any movement conditions were tested. The arthrometer consists of a footplate that secures the foot within the device by way of calcaneal and dorsal talar clamps. IE angles are measured via the relative movement of the footplate against a tibial pad using a six degree-of-freedom spatial kinematic linkage system. Total IE laxity was calculated as the summative angle reached at 3Nm inversion torque and 3 Nm eversion torque (Kovaleski et al., 1999). Arthrometry measures were taken barefoot.

Two movement conditions were tested within the laboratory; a cutting manoeuvre and a netball landing task. The cutting task involved a three step jogging approach towards the force platform followed by a 45 degree directional change to the non-test leg side of the laboratory upon contact with the force platform with the test leg. The netball landing task (catch and stop) involved a chest height ball pass thrown with a flat trajectory to the participant as they approached the force platform at running speed (Stuelcken, Greene, Smith & Vanwanseele, 2013). Upon catching the ball and landing, the participant was permitted to step forward and ground the non-test leg but, in keeping with the netball footwork rule, was not permitted to re-ground the test leg (Stuelcken et al., 2013). All laboratory trials were performed barefoot with no external prophylactic ankle supports. Familiarisation with each movement condition was conducted prior to testing until the participant felt comfortable with each movement and was landing on the force platform with the test leg. During both movement conditions, the test leg was required to make full contact within the force platform (Kistler, Winterthur, Switzerland) for a trial to be successful. Five successful trials were recorded for each condition.
Reflective markers were placed on anatomical landmarks to define the positioning of the pelvis, shank, rearfoot, forefoot and hallux. The rearfoot was defined by a triad marker wand fixed to the skin of the posterior calcaneus via a plastic stirrup with double sided tape. The three dimensional movement of the reflective markers during all trials was captured at 200Hz with a 14 camera motion analysis system (Eagle Cameras, Cortex 3.3, Motion Analysis Corporation, Santa Rosa, CA, USA). Ground reaction force data were recorded from a force platform (Model 9287, Kistler, Winterthur, Switzerland).
For analysis, joint centres were quantified using a three-dimensional model in Kintrak (Version 6.2, Canada) before mean IE kinematic ensemble data were collated using Matlab (Mathworks, USA). Frontal plane kinematics were analysed from foot strike to toe-off during the cutting task and from foot strike until stabilisation during the 'catch and stop' task.

RESULTS AND DISCUSSION: Despite previous research finding no association between the number of prior ankle sprains and joint laxity (Liu, Gustavsen & Kaminski, 2013), participant 4 had the highest number of previous ankle sprains and the largest arthrometry IE angle (Table 1). During the cutting task, the same participant displayed the largest magnitude of frontal plane ankle range of motion as well as the largest eversion angle during stance phase (Figure 1). Frontal plane kinematics have been shown to display greater inter-subject variability when compared to sagittal plane motion (De Wit, De Clercq & Aerts, 2000) and inter-subject variability during the cutting task of the current study is observed in Figure 1.

Table 1.
Ankle joint data for each participant within the current pilot study.

	Participant number			
	1	2	3	4
Previous ankle sprains (n)	0	0	2	3
Arthrometry inversion-eversion angle (deg)	29.3	28.3	30.5	45.0
Frontal plane range of motion during stance phase (deg)				
Cutting	9.1	13.3	10.3	21.2
Catch and stop	18.1	18.1	15.8	21.3
Inversion angle at foot strike (deg)				
Cutting	13.0	9.2	9.9	10.0
Catch and stop	12.9	3.4	6.5	6.5

A multiple correlation coefficient of 0.84 and 0.68 was found when relating arthrometry measured IE laxity with frontal plane range of motion during the stance phase of the cutting movement and ‘catch and stop’ movement, respectively (Figure 2). Essentially, only the results of participant 4 make the correlations for both movement conditions as strong as they are. More netball players are required to examine any true relationship between the variables.

It appears that there is preliminary evidence to suggest that mechanical joint laxity as measured with an instrumented arthrometer may be related to frontal plane ankle range of motion during netball specific functional tasks. The small sample size of this pilot data set make inferences in regards to interpretation difficult and by no means are the results conclusive.

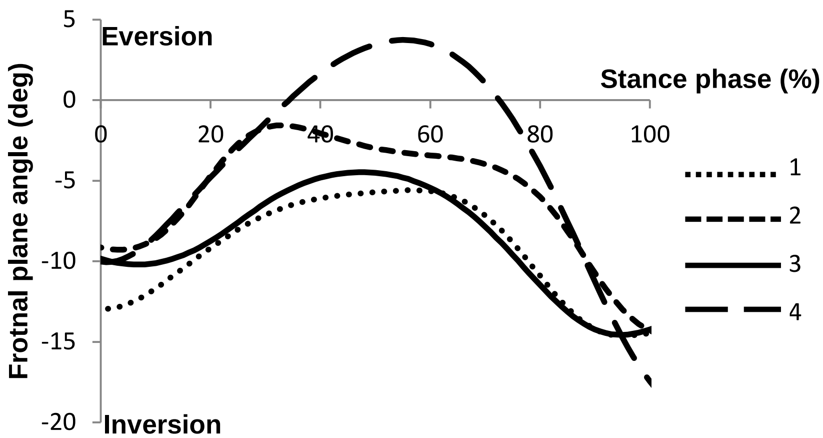

Figure 1. Ankle joint frontal plane angles normalised for each participant as a percentage of stance phase during the cutting movement.

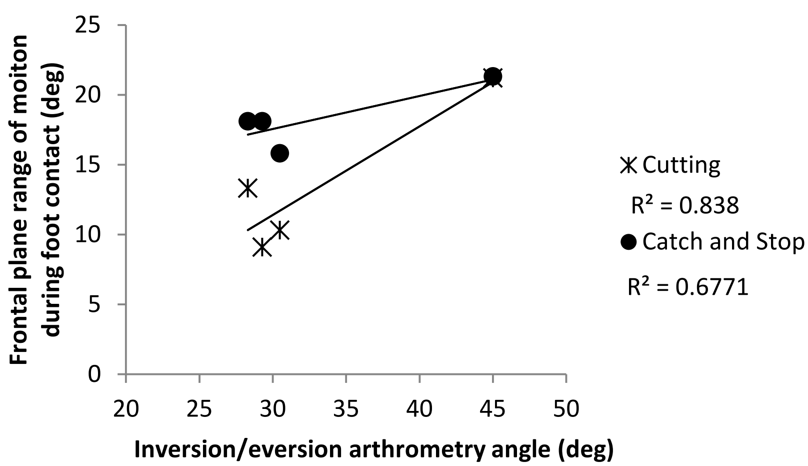

Figure 2. Arthrometry measures and frontal plane range of motion during the stance phase of the landing tasks.

The addition of extra support in the form of shoes or braces alters lower limb joint characteristics (De Wit et al., 2000). During a unidirectional netball landing task similar to the ‘catch and stop’ task of the current study, a shod and braced condition showed a reduction in ankle frontal plane range of motion as well as a less inverted position at foot strike when compared to a purely shod condition (Vanwanseele et al., 2014). As netball is a sport played under shod conditions, it is important for the extension of the current study to investigate the relationship between arthrometry measured joint laxity and the potentially supportive effect netball shoes have on functional movement tasks.

As initial forefoot contact is the most common landing pattern in netball (Hopper, Lo, Kirkham & Elliott, 1992), and increased plantar flexion at foot strike is likely to increase the susceptibility to sustain an ankle sprain (Wright, Neptune, van den Bogert & Nigg, 2000), it is also important that an extension of this study investigates the sagittal plane kinematics of the ankle at foot strike during the two laboratory movement conditions. Furthermore, the effect of shoes on sagittal plane kinematics and kinetics should be explored as, during a sidestep cutting task, reduced sagittal plane ankle range of motion was found when a brace was added to the shod condition (Greene, Stuelcken, Smith & Vanwanseele, 2014).

CONCLUSION: With a larger sample size, if laboratory based measures can be linked to ankle laxity measurements then arthrometry provides a more time efficient and cost effective real-time solution to gain insight into landing kinematics. This link may be able to identify netball players who could benefit from additional external prophylactic ankle supports to restrict frontal plane range of motion during training and matches and ultimately lead to a reduction of ankle injuries occurring in the sport.

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Acknowledgement

The collection of data within this study was assisted by a New South Wales Sporting Injuries grant, New South Wales, Australia (2012).